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File Code: 3420 **Date:** November 8, 2005
Route To:

Subject: Evaluation of Insects and Diseases Affecting CEEMS Certification Stand.

To: Paul Callaway, Timber Manager, North Kaibab RD

I recently met with you to view and discuss insects and diseases present in your CEEMS certification stand. This letter describes our findings and provides technical information on the biology, ecology, and management of the insects and pathogens of concern.

The 74 acre stand is located in the Telephone Hill Assessment Area, south of Jacob Lake Lodge. The overstory vegetation is dominated by ponderosa pine with a substantial component of white fir and Douglas fir, and the understory is densely stocked with white fir. Small clones of aspen are dispersed throughout the site. Total stocking is about 82 square feet of basal area per acre, averaging 225 trees per acre >1" dbh, but over 1,000 trees per acre <1"dbh. The stand is within a Northern Goshawk foraging area and the Arizona Trail runs through the site.

Current management emphasis is to maintain ponderosa pine as the dominant vegetation type, enhance aspen clones, increase tree growth and vigor, and minimize the risk of stand replacing wildfire.

Pathogen and Insects

We found at least one insect or disease agent causing mortality and/or dieback in each tree species. Small groups of 8"-to-12"dbh white fir were killed by fir engraver beetle. This beetle has caused periodic mortality on the NKRD since the early 1990's. Although we checked the roots of dead white fir for annosus root disease, only a root of an old fallen log was observed with signs of annosus decay.

Much larger sized ponderosa pine trees, those over 20"dbh, were killed by western pine beetle in the past few years. We removed the bark at the base of these trees but found no signs of armillaria root disease present in the cambium. Very little southwestern dwarf mistletoe infection in ponderosa pine was observed along the southern border of the stand.

Branch dieback and whole tree mortality were observed in many of the small aspen clones. It looked similar to symptoms seen throughout Northern Arizona over the past 6 years, related to the recent drought. Although the crowns of trees dieback, the root systems often sucker to regenerate the clone. Many species of canker fungi were also present in these clones.

Groups of dwarf mistletoe infected Douglas fir are scattered over the site. Four of your fifteen survey points were infected. Dwarf mistletoe ratings (DMR) based on Hawksworth's[1] 6-class system were calculated from survey data. Average infection levels per point were relatively low, DMR's of 0.3 to 0.5. Total stand average DMR was 0.5.

Technical Insect and Disease Information

Bark Beetles
Fir Engraver Beetle: *Scolytus ventralis*

The fir engraver beetle attacks white fir in the Southwest. Outbreaks most often occur in areas where trees have been stressed by drought or defoliation. Mortality has also been associated with dense stands, dry sites, dwarf mistletoe, and root pathogens[2]. Beetles attack standing trees as well as freshly cut logs and recent wind throws that are greater than 4" in diameter. Fir engravers require 1-2 years to complete their life cycle. In most areas one year is sufficient but at higher altitudes two years may be required[3].

External evidence of attack consists of entrance holes, boring dust and pitch streaming. Entrance holes are about 0.1" wide and located at the junction of a branch and the trunk. Reddish brown or white boring dust may be found along the trunk, in bark crevices and in cobwebs. Streams of clear pitch often flow from entrance tunnels down the bole.

Under the bark, adults excavate egg galleries in the sapwood. The egg gallery is horizontal or perpendicular to the grain of wood. Larval galleries extend at right angels to the egg galleries.

Effects of attack can include tree mortality, top kill and in some cases branch girdling and flagging. Sometimes only strips or patches of bole are attacked, and trees recover if sufficient areas of healthy cambium remain. Effect of attack on resource management varies depending on the degree of mortality and the particular resource values involved. Scattered and even clumps of mortality can be beneficial to wildlife by creating snags, down woody material, and openings. Bark beetles are also a food source for some species of wildlife. Extensive mortality, though, reduces canopy cover in affected areas, which may be detrimental to hiding and thermal cover. Further, dead trees and dry needles increase the risk of fire. Although effects of bark beetles on timber resources are typically negative, in the Southwest true firs are not considered a valuable timber species and fir mortality can provide more growing space for pine.

Where fir engraver mortality is a concern, risk of mortality can be reduced by maintaining fir stands in good growing condition. Managing stands to minimize effects of root disease and defoliators (e.g. white fir needle miner, *Epinotia meritana*) are recommended. Periodic fir engraver mortality may be expected in areas where white fir becomes established on relatively dry sites.

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[1] Hawksworth, F.G. 1977. The 6-class dwarf mistletoe rating system. USDA Forest Service, General Technical Report RM-48. 7pp.
[2] Ferrell, G.T. 1986. Fir engraver. USDA For. Serv. Forest Insect and Disease Leaflet 13. 8 p.
[3] Furniss, R.L., and V.M. Carolin. 1977. Western forest insects. USDA Forest Service, Misc. Publication 1339. 654 p.

Western Pine Beetle: *Dendroctonus brevicomis*

Western pine beetle attacks ponderosa pine in the Southwest. Between two and four generations are produced per year depending on latitude and elevation[4]. Flight and attacks start in late spring or early summer and continue until the onset of cold weather. This insect usually breeds in scattered, slow growing overmature trees and diseased or damaged trees. Group killing is also common in densely stocked stands of young sawtimber. However, trees under 6"dbh are seldom attacked. Environmental stresses which permanently weaken individual or small groups of trees (root diseases, mistletoes, mechanical damage) or temporarily weaken whole stands (droughts, defoliators, fires) predispose trees to attack and create conditions for outbreaks to occur.

There are a number of natural enemies of this insect including woodpeckers, and several parasitic and predatory insects. However, the main factor thought to influence occurrence of outbreaks is the abundance of suitable hosts.

Prevention of outbreaks is the most effective way of reducing losses. Unacceptable losses can be prevented in most circumstances (barring severe drought) by maintaining thrifty, vigorous trees. Reducing stocking to less than 70 percent of the basal area necessary for full site utilization, relieves competitive stress among remaining trees which makes them less susceptible to attack.

Root Disease
Armillaria Root Disease: *Armillaria spp.*

Armillaria root disease, or shoestring root rot, affects several species of conifers throughout the West. All conifer species in the Southwestern Region are susceptible, but nonresinous conifers, such as Douglas fir and spruce, are more susceptible than ponderosa pine and southwestern white pine. In the past, all armillaria root disease was attributed to one species, *Armillaria mellea*. However, scientists now refer to a whole complex, composed of approximately 10 distinct species which are differentiated based on morphological, biological, and ecological properties. While some species are purely saprophytic (utilize dead wood), there are a few host specific pathogens (a parasite capable of causing disease in a particular host or range of hosts)[5]. *A. ostoyae* is the species most often associated with armillaria root disease of conifers in the Western United States.

Armillaria quickly invades the root system of infected trees when they are cut or killed. The pathogen survives for decades as a saprophyte on woody tissues of stumps and snags, which act as a food base. Spread occurs when healthy roots contact decayed roots, or by rhizonmorphs (fungal strands of hyphae) which can grow through the soil for short distances and penetrate the bark of healthy roots. Armillaria attacks the roots and root collar of trees of all ages, killing the cambium and inner bark and causing a decay of both sapwood and heartwood. Rapid death occurs when the fungus advances rapidly through the inner bark and girdles the root collar.

The ability of armillaria to kill trees is greatly influenced by host vigor. It is often very aggressive in young stands less than 30 years old. The advance of the fungus is much slower in older, rapidly growing trees, in which resin secretion and callus formation blocks spread of

[4] DeMars, Jr., C.J., and B.H. Roettgering. 1982. Western Pine Beetle. USDA Forest Service, Forest Insect and Disease Leaflet 1. 8 p.
[5] Shaw III, D.G., and G.A. Kile. 1991. Armillaria root diseases. USDA Forest Service Agricultural Handbook 691. 233 p.

disease. During periods of drought, infected trees of all ages are often affected. However, with a return to average or better moisture conditions, the rate of mortality of large infected trees nearly ceases. Trees infected with armillaria or other diseases are often predisposed to attack by bark beetles or wood borers[6][7]. Infestations often coincide with or immediately follow periods of subnormal precipitation.

Armillaria root disease can be called a "disease of the site", since the pathogen often survives for extended periods of time in woody material such as snags and stumps. Infection centers are typically centered on an infected stump acting as a food base for the fungus. However, infection must take place while trees are alive because pathogenic species do not colonize in infected dead root systems.

Treatment recommendations are best directed toward limiting disease buildup or reducing its impact. Treatment options include: minimizing stress to and wounding of residual trees; reducing the food base of the fungus by limiting the number of large stumps (stumps less than 9"dbh do not make a good food base), reforesting heavily infected stands with less susceptible species; maintaining vigorous tree growth[8].

Annosus Root Rot: *Heterobasidion annosum*

H. annosum causes serious losses in conifer forests throughout the world. There appear to be two types of annosus in North America, each of which has specific host preferences. One type infects true firs, and sometimes spruce and Douglas fir. The other infects ponderosa pine. In the Southwest, annosus root disease is the second most common root disease of conifers. It has been described as being present across all forest types, but overall losses are low and occur mostly in true fir[9][10].

Spores of *H. annosum* are produced on conks in decayed stumps or on roots of windthrown trees. The most common means of initial entry of *H. annosum* into a site is via airborne spores that germinate on freshly cut stumps and basal wounds. Mycelium of *H. annosum* quickly colonizes exposed wood and grows into roots. Transmission to adjacent trees occurs via root contacts. In live trees, the fungus decays woody root systems and then advances to the root collar where it may surface to the cambium and kill by girdling as in ponderosa pine, or progress more slowly through roots to the stem and cause butt decay as in true fir. Usually the losses caused by annosus root rot in firs are due to decay in butt logs, increased probability of windthrow, and increased susceptibility to insect attack. Although annosus root rot can kill ponderosa pine seedlings and saplings, this is rare in white fir.

H. annosum leads to crown thinning and mortality or windthrow, the latter of which can occur

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[6] Hadfield, J.S., Mathiasen, R.L., and F. G. Hawksworth. 2000. Douglas-fir dwarf mistletoe. USDA Forest Service, Forest Insect And Disease Leaflet 54. 10 p.

[7] Tkacz, B., and Schmitz, R.F. 1986. Association of an endemic mountain pine beetle population with lodgepole pine infected by Armillaria root disease in Utah. USDA For. Serv. Res. Note INT-353.

[8] Filip, G.M., D.J. Goheen, D.W. Johnson and J.H. Thompson. 1989. Precommercial thinning in a ponderosa pine stand affected by armillaria root disease: 20 years of growth and mortality in central Oregon. West J. Appl. For. 4(2): 58-59.

[9] Mielke, J.L, and R>W. Davidson. 1947. Notes on some western wood-decay fungi. Plant Dis. Rep. 31:27-31.

[10] Wood, R.E. 1983. Mortality caused by root diseases and associated pests on six National Forests in Arizona and New Mexico. USDA Forest Service, R-3 83-13. 31 p.

before aboveground symptoms are evident. Like *Armillaria spp*., *H. annosum* is a common decayer of dead woody material as well as a pathogen. Infected trees are predisposed to attack by bark beetles.

Treatment recommendations for annosus root disease are similar to those for armillaria root disease and should focus on limiting disease buildup. Treatment options include minimizing stress to and wounding of residual trees and reducing the food base of the fungus by limiting the number of large stumps (stumps less than 9"dbh do not make a good food base). Because the two types of annosus apparently do not transmit through root contacts from one host species to the other, conversion to another conifer species or aspen is probably the most effective means of managing the disease. It allows time for the fungus, which is capable of surviving in centers for as long as 50 years, to die out, while still maintaining at least partial productivity of the site. If species conversion is not practical, distinct, identifiable infection centers should be delineated and avoided when susceptible species are planted.

Dwarf Mistletoes:
Arceuthobium douglasii
Arceuthobium vaginatum subsp. *cryptopodum*

Dwarf mistletoes are the most prevalent disease agents in southwestern coniferous forests. It is estimated that over 30 percent of the lands classified as commercial ponderosa pine habitat are infected with southwestern dwarf mistletoe (SWDM), while over fifty percent of Douglas fir habitat is thought to be infected with Douglas fir dwarf mistletoe.

Dwarf mistletoes are parasitic, seed-bearing plants that depend on their hosts almost completely for water and nutrients. Infection by all DM species takes place through the bark on needle-bearing portions of twigs. A specialized rootlike structure that is in contact with the phloem and xylem of host trees is produced, from which the parasite obtains most of its nutrients and water. The aerial shoots appear between 2 to 5 years after infection; this period of infection before shoots are visible is known as the latent period.

Disease spreads by explosively released seeds, expelled to distances typically ranging from 10 to 40 feet. Spread of dwarf mistletoe is a function of stand structure, density, age, and site index, and averages one or two feet a year. Spread is most efficient and rapid from an infected overstory to an understory and slowest through a dense even-aged or multi-species stand.

In general, dwarf mistletoe infection alters tree form, reduces vigor and growth rates, and increases susceptibility to other damaging agents. Infected host trees are slowly weakened and eventually killed as the parasite drains them of water and nutrients[11]. Survival of the host is influenced by the severity of dwarf mistletoe infection. Eventually there are changes in the structure and function of infected forest communities[12] [13].

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[11] Tocher, R.D.; Gustafson, S.W.; Knutson, D.M. 1984. Water metabolism and seedling photosynthesis in dwarf mistletoes. In: Hawksworth, F.G.; Scharpf, R.F., tech. coords. Biology of dwarf mistletoes: Proceedings of the symposium; 1984 August 8; Fort Collins, CO. General Technical Report RM-111. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 62-69.
[12] Parmeter, J.R., Jr. 1978. Forest stand dynamics and ecological factors in relation to dwarf mistletoe spread, impact, and control. p. 16-30, In: Proceedings of the symposium on dwarf mistletoe control through forest

Within a few years an infected branch elongates at an abnormally rapid rate, forms a broom and significantly alters the growth behavior of the tree: height growth is drastically reduced, diameter growth slows down, and needle and branch death occur. Topkill is common in severely infected Douglas fir trees, especially trees with large witches' brooms lower in the crowns. Douglas fir brooms are also known to alter fire behavior: Dense brooms are intensely flammable; brooms often fail during winter with heavy snow loading and lie at the base of trees where they serve to catch live brooms on fire; ignited brooms are said to travel great distances.

Dwarf mistletoe infection and the witches' brooms formed are an important component of wildlife habitat[14]. In a study of Douglas fir dwarf mistletoe brooms in northern and central Arizona, significantly more use by birds and mammals was found in broomed versus unbroomed trees. Red squirrels were the primary mammals to use Douglas fir witches brooms (Hedwall, S. et al submitted to Journal of wildlife management).

Mathiasen et.al.[15] found mortality of Douglas fir in stands severely infested with dwarf mistletoe was three to four times that of healthy stands. Although little dwarf mistletoe infection occurs in trees under 25 years of age, mortality of mature Douglas fir is greater with lower infection levels than is found for southwestern dwarf mistletoe of ponderosa pine. However, the greater level of mortality of infected Douglas fir may be related to an association with root disease infection, which is infrequent in ponderosa pine in the Southwest.

Wildfires are one of the primary ecological factors in determining the distribution and intensity of dwarf mistletoes in unmanaged coniferous forests[16]. Relatively complete burns tend to have a sanitizing effect on infected stands, while partial burns can lead to rapid infection of regeneration if scattered infected trees remain following the fire. Surface fires can partially sanitize areas by pruning brooms in the lower crown of infected trees and reducing the number of heavily infected trees, since the latter have been shown to have decreased survival probabilities compared to uninfected or lightly infected trees.

Some basic features of dwarf mistletoes make them ideal candidates for cultural management[17]. First, Infected trees are easy to detect. Dwarf mistletoes are obligate parasites that require a living host to survive and once an infected tree or branch is cut, the mistletoe dies, and it is unnecessary to burn or destroy the slash. Dwarf mistletoes are species specific allowing nonhost tree species to be selected for leave trees. Dwarf mistletoes have relatively long life cycles and

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management. Robert F. Scharpf and John R. Parmeter, Jr., Tech. Coords., April 11-13, 1978, Berkeley, DA: USDA Forest Service General Technical Report PSW-31, 190 p.

[13] Tinnin, R.O. 1984. The effect of dwarf mistletoe on forest community ecology. P.117-122, In: Biology of Dwarf Mistletoes: Proceedings of the symposium on dwarf mistletoe control through forest management. Robert F. Scharpf and John R. Parmeter, Jr., Tech. Coords., April 11-13, 1978, Berkeley, DA: USDA Forest Service General Technical Report PSW-31, 190 p.

[14] Parks, C.G., E.L. Bull, R.O. Tinnin, J.F. Shepherd, A.K. Blumton. 1999. Wildlife use of dwarf mistletoe brooms in Douglas-fir in northeast Oregon. West J. Appl. For. 14(2): 100-105.

[15] Mathiasen, R.L., C.B. Edminster, and F.G. Hawksworth. 1990. Infection of young Douglas-firs by dwarf mistletoe in the Southwest. Great Basin Naturalist. 50(1):67-72.

[16] Alexander, M.E. and F.G. Hawksworth. 1976. Fire and dwarf mistletoes in North America coniferous forests. Journal of Forestry. 74(7):446-449.

[17] Johnson, D.W. and F.G. Hawksworth. 1985. Dwarf mistletoes: candidates for control through cultural management. In: Insect and disease conditions in the United States, 1979-1983. General Technical Report WO-46. Washington DC: U.S.D.A Forest Service: 48-55.

slow spread rates. Treatment effectiveness in lightly to moderately infected trees is comparable to that of uninfected trees[18]. Seeds are dispersed at short distances, so if distance between trees is increased, spread is slowed.

Summary

There are many options for managing this stand due to the presently low levels of insect and disease activity. Bark beetle risk should decrease if stand density is reduced and ponderosa pine is the preferred leave tree species. Douglas fir dwarf mistletoe levels can be reduced during thinning by targeting the removal of infected trees. Also, root disease levels are not expected to increase if smaller diameter trees are selected for removal.

If you have any questions regarding this evaluation, please let us know. I can be reached at (928) 556-2075 (mfairweather@fs.fed.us).

/s/ Mary Lou Fairweather
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cc:
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Debra Allen-Reid

[18] Tinnin, R.O., C.G. Parks and D.M. Knutson. 1999. Effects of Douglas-fir dwarf mistletoe on trees in thinned stands in the Pacific Northwest. Forest Science. 45(3):359-365.